

S.N. 09/920,281

Attorney Docket No.: RD-26,350

The listing of claims will replace all prior versions, and listings, of claims in the application.

### **LISTING OF CLAIMS**

**Claim 1** (currently amended): An opto-acoustic wave sensor for detecting a presence, determining a location, and quantifying an amount of a first chemical species, said opto-acoustic wave sensor comprising:

- (1) an opto-acoustic wave sensing element that comprises an acoustic wave element, two electrodes coupled to said acoustic wave element, and a coating being disposed on at least one portion of said acoustic wave element and comprising at least one reagent that is capable of undergoing a selective chemical interaction with said first chemical species to be detected to yield at least one optically detectable interaction product, said optically detectable interaction product comprising a second chemical species;
- (2) a source of electromagnetic ("EM") radiation optically coupled to said opto-acoustic wave sensing element, EM radiation from said source being modified by said interaction product to produce modified EM radiation, and an optical property of said modified EM radiation being matched to an identity of said interaction product;
- (3) a first detector for detecting a change in a property of said opto-acoustic wave sensing element, which property is selected from the group consisting of mass, viscoelastic, and dielectric properties; said change in said property of said opto-acoustic wave sensing element being irreversible and providing a quantitation of said first chemical species; and
- (4) a second detector for detecting said optical property of said modified EM radiation; wherein said identity of said interaction product provides an identity of said second chemical species;

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wherein said optical property of said interaction product is selected from the group consisting of absorbance of said EM radiation from said source and emission of EM radiation from said interaction product.

**Claim 2** (original): The opto-acoustic wave sensor according to claim 1, wherein said acoustic wave element is selected from the group consisting of a TSM sensor, a SAW sensor, a FPW sensor, and a SH-APM sensor.

**Claim 3** (original): The opto-acoustic wave sensor according to claim 1, wherein said acoustic wave element is a TSM sensor.

**Claim 4** (original): The opto-acoustic wave sensor according to claim 3, wherein said TSM sensor is a QCM.

**Claim 5** (original): The opto-acoustic wave sensor according to claim 4, wherein said QCM comprises a quartz crystal element selected from the group consisting of an AT-cut quartz crystal element and a BT-cut quartz crystal element.

**Claim 6** (original): The opto-acoustic wave sensor according to claim 1, wherein said acoustic wave element is a SAW sensor.

**Claim 7** (original): The opto-acoustic wave sensor according to claim 4, wherein said coating is disposed on at least one electrode of said sensor.

**Claim 8** (original): The opto-acoustic wave sensor according to claim 6, wherein said coating is disposed on a surface of said sensor and between said electrodes.

**Claim 9** (original): The opto-acoustic wave sensor according to claim 1, wherein said coating comprises a porous permeable polymeric material.

**Claim 10** (original): The opto-acoustic wave sensor according to claim 9, wherein said polymeric material is selected from the group consisting of polytetrafluoroethylene ("PTFE"), poly(vinyl chloride) ("PVC"), poly(vinyl alcohol) ("PVA"), polyurethane, polyolefins such as polyethylene or polypropylene, polycarbonate, polystyrene, polyamide, poly(vinylidene

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fluoride) ("PVDF"), polyarylsuphones, polyacrylonitrile, polyether, polyetherurethane, poly(ether thioether), poly(methyl methacrylate), polyvinylpyrrolidone, polysiloxane, nylon, cellulose and its derivatives, copolymers thereof, and blends thereof.

**Claim 11** (original): The opto-acoustic wave sensor according to claim 10, wherein said coating has a thickness in a range from about 10 nm to about 100 micrometers.

**Claim 12** (original): The opto-acoustic wave sensor according to claim 11, wherein said thickness is preferably in a range from about 20 nm to about 50 micrometers, and more preferably from about 20 nm to about 10 micrometers.

**Claim 13** (original): The opto-acoustic wave sensor according to claim 9, wherein said porous permeable polymeric material has pore size in a range from about 1 nm to about 200 nm.

**Claim 14** (original): The opto-acoustic wave sensor according to claim 13, wherein said pore size is preferably in a range from about 1 nm to about 100 nm, and more preferably from about 1 nm to about 50 nm.

**Claim 15** (original): The opto-acoustic wave sensor according to claim 1, wherein said coating comprises a porous solid substrate supporting a polymeric material selected from the group consisting of polytetrafluoroethylene ("PTFE"), poly(vinyl chloride) ("PVC"), poly(vinyl alcohol) ("PVA"), polyurethane, polyolefins such as polyethylene or polypropylene, polycarbonate, polystyrene, polyamide, poly(vinylidene fluoride) ("PVDF"), polyarylsuphones, polyacrylonitrile, polyether, polyetherurethane, poly(ether thioether), poly(methyl methacrylate), polyvinylpyrrolidone, polysiloxane, nylon, cellulose and its derivatives, copolymers thereof, and blends thereof.

**Claim 16** (original): The opto-acoustic wave sensor according to claim 11, wherein said porous substrate comprises a material selected from the group consisting of glass, quartz, and piezoelectric materials.

**Claim 17** (original): The opto-acoustic wave sensor according to claim 1, wherein said coating is porous and said reagent is chemically attached to a surface of said coating.

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**Claim 18** (original): The opto-acoustic wave sensor according to claim 1, wherein said coating is porous, and a mixture of said reagent and a matrix material is deposited in said porous coating.

**Claim 19** (original): The opto-acoustic wave sensor according to claim 1, wherein said EM radiation has a wavelength is in a range from UV to IR.

**Claim 20** (original): The opto-acoustic wave sensor according to claim 19, wherein said wavelength is in a range from about 100 nm to about 1mm.

**Claim 21** (previously canceled).

**Claim 22** (original): The opto-acoustic wave sensor according to claim 1, wherein said first detector measures a change in a resonant frequency of said acoustic wave element and relates said change to a change in a mass thereof.

**Claim 23** (original): The opto-acoustic wave sensor according to claim 1, wherein said first detector measures a change in at least one parameter of the acoustic wave-sensing element, said at least one parameter being selected from the group consisting of fundamental oscillation frequency, harmonic oscillation frequency, impedance phase and amplitude, impedance phase and attenuation, wave velocity, wave attenuation, capacitance, and conductance and relates said change to a change in a mass of said acoustic wave-sensing element.

**Claim 24** (original): The opto-acoustic wave sensor according to claim 1, wherein said second detector measures a optical signal selected from the group consisting of absorbance and intensity of an emission of EM radiation.

**Claim 25** (original): The opto-acoustic wave sensor according to claim 1, wherein said chemical species is selected from the group consisting of halogenated hydrocarbons, polynitroaromatic hydrocarbons, mono-substituted benzene, aromatic aldehydes, aromatic amines, and mixtures thereof.

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**Claim 26** (previously presented): The opto-acoustic wave sensor according to claim 25, wherein said halogenated hydrocarbons are trichloroethylene, trichloroethane, chloroform, bromoform, chlorodibromomethane, and bromodichloromethane.

**Claim 27** (original): The opto-acoustic wave sensor according to claim 25, wherein said polynitroaromatic hydrocarbons are 1,3,5-trinitrobenzene; 2,4,6-trinitrobiphenyl; 2,3',4,5',6-pentanitrobiphenyl; 2,2',4,4',6,6'-hexanitrobiphenyl; 2,4,6-trinitrotoluene; 2,2',4,4',6,6'-hexanitrobiphenyl; 2,2',4,4',6,6'-hexanitrostilbene; 2,2',4,4'-tetranitrobiphenyl; 3,3',5,5'-tetranitrobiphenyl; 2,2',6,6'-tetranitrobiphenyl; 1,4,5,8-tetranitronaphthalene; 1,3-dinitrobenzene; 2-ethoxy-1,3,5-trinitrobenzene; 2-methyl-1,3-dinitrobenzene; 2,4-dimethyl-1,3-dinitrobenzene; and mixtures thereof.

**Claim 28** (original): The opto-acoustic wave sensor according to claim 25, wherein said mono-substituted benzene has a formula of Ar-X, wherein Ar is a phenyl radical and X is a radical selected from the group consisting of  $-\text{CH}_3$ ,  $-\text{OCH}_3$ ,  $-\text{C}_6\text{H}_5$ ,  $-\text{SCH}_3$ , and  $-\text{SC}_6\text{H}_5$ .

**Claim 29** (original): The opto-acoustic wave sensor according to claim 25, wherein said aromatic aldehydes are benzaldehyde, 1-naphthaldehyde, 9-anthraldehyde, 4-dimethylaminocinnamaldehyde, 2-nitrobenzaldehyde, and 4-nitrobenzaldehyde.

**Claim 30** (original): The opto-acoustic wave sensor according to claim 25, wherein said aromatic amines are pyridine and alkyl-substituted pyridines.

**Claim 31** (original): The opto-acoustic wave sensor according to claim 1 further comprising at least one optical waveguide optically coupled to said opto-acoustic wave sensing element; said optical waveguide receiving EM radiation generated by said source of EM radiation and carrying EM radiation to and from said opto-acoustic wave sensing element.

**Claim 32** (original): The opto-acoustic wave sensor according to claim 31, wherein said optical waveguide comprises an optical fiber.

**Claim 33** (original): The opto-acoustic wave sensor according to claim 31, wherein said optical waveguide comprises a bundle of optical fibers.

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**Claim 34** (original): The opto-acoustic wave sensor according to claim 32 further comprising a lens that is interposed between said optical fiber and said opto-acoustic wave sensing element.

**Claim 35** (original): The opto-acoustic wave sensor according to claim 1, wherein said at least one reagent is selected from the group consisting of organic, inorganic, biochemical molecules, and nucleic acid.

**Claim 36** (currently amended): An opto-acoustic wave sensor for detecting a presence, determining a location, and quantifying an amount of a first chemical species, said opto-acoustic wave sensor comprising:

- (1) an opto-acoustic wave sensing element that comprises an acoustic wave element, two electrodes coupled to said acoustic wave element, and a coating being disposed on at least one portion of said acoustic wave element and comprising at least one reagent that is capable of undergoing a selective chemical interaction with said first chemical species to be detected to yield at least one optically detectable interaction product, said optically detectable interaction product comprising a second chemical species;
- (2) a source of electromagnetic ("EM") radiation optically coupled to said opto-acoustic wave sensing element, EM radiation from said source being modified by said interaction product to produce modified EM radiation, and an optical property of said modified EM radiation being matched to an identity of said interaction product;
- (3) a first detector for detecting a change in a property of said opto-acoustic wave sensing element, which property is selected from the group consisting of mass, viscoelastic, and dielectric properties; said change in said property of said opto-acoustic wave sensing element being irreversible and providing a quantitation of said first chemical species; and
- (4) a second detector for detecting said optical property of said modified EM radiation; wherein said identity of said interaction product provides an identity of said second chemical species;

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wherein said coating comprises a porous solid substrate supporting a polymeric material selected from the group consisting of polytetrafluoroethylene ("PTFE"), poly(vinyl chloride) ("PVC"), poly(vinyl alcohol) ("PVA"), polyurethane, polyolefins such as polyethylene or polypropylene, polycarbonate, polystyrene, polyamide, poly(vinylidene fluoride) ("PVDF"), polyarylsuphones, polyacrylonitrile, polyether, polyetherurethane, poly(ether thioether), poly(methyl methacrylate), polyvinylpyrrolidone, polysiloxane, nylon, cellulose and its derivatives, copolymers thereof, and blends thereof; said acoustic wave element is selected from the group consisting of a TSM sensor, a SAW sensor, a FPW sensor, and a SH-APM sensor; said optical property is selected from the group consisting of absorbance and intensity of emission of EM radiation; and said wavelength is in a range from about 100 nm to about 1mm; and

wherein said optical property of said interaction product is selected from the group consisting of absorbance of said EM radiation from said source and emission of EM radiation from said interaction product.

**Claim 37** (canceled).

**Claim 38** (canceled).

**Claim 39** (canceled).

**Claim 40** (canceled).

**Claim 41** (canceled).

**Claim 42** (canceled).

**Claim 43** (canceled).

**Claim 44** (canceled).

**Claim 45** (canceled).

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**Claim 46** (canceled).

**Claim 47** (canceled).

**Claim 48** (canceled).

**Claim 49** (canceled).

**Claim 50** (canceled).

**Claim 51** (canceled).

**Claim 52** (canceled).

**Claim 53** (canceled).

**Claim 54** (canceled).

**Claim 55** (canceled).

**Claim 56** (canceled).

**Claim 57** (canceled).

**Claim 58** (canceled).

**Claim 59** (canceled).

**Claim 60** (canceled).

**Claim 61** (canceled).

**Claim 62** (canceled).



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**Claim 63** (canceled).

**Claim 64** (canceled).

**Claim 65** (canceled).

**Claim 66** (canceled).

**Claim 67** (canceled).

**Claim 68** (canceled).

**Claim 69** (canceled).

**Claim 70** (canceled).

**Claim 71** (canceled).

**Claim 72** (canceled).

**Claim 73** (canceled).